International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 7 Issue 3, May-June 2023 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Modelling of Solar PV and Optimization of Chopper Based PV Array using Fuzzy Control System as Per Climatic Conditions

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ABSTRACT

In today's era a lot of steps are taken to encourage the use of renewable source of energy for the energy generation, Solar Energy are very popular now a days for the clean energy and many researches are going on to increase the efficiency of solar generation system. Due to the limitation of solar radiations and intensity of irradiation dependency on the generation system, it is necessary to design the control system according to the weather and climatic conditions by studying in details and to design a control system with artificial intelligence to extract and generate maximum power and for this purpose fuzzy control system is also very popular these days, In this work a fuzzy logic control system has been designed for the gate pulse with the predefined rules and try to achieve the desired outputs. Simulation results are shown and discussed with the Matlab/Simulink simulation software to validate the proposed control strategy. This control strategy has a good performance in terms of dynamic response and output.

KEYWORDS: *Maximum power point tracking system (MPPT), Pulse Width Modulation (PWM), Insulated gate bipolar transistor (IGBT), Total harmonic distortion (THD), static synchronous compensator (STATCOM),), and fuzzy logic control (FLC),Perturbation & Observation (P&O)*

How to cite this paper: Manish Kumar Yadav | Shailendra Verma "Modelling of Solar PV and Optimization of Chopper Based PV Array using Fuzzy Control System as Per Climatic Conditions" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-7 | Issue-3, June 2023, pp.1077-1086, URL: www.ijtsrd.com/papers/ijtsrd57550.pdf

IJTSRD57550

INTRODUCTION

Renewable energy used for heating increased by 2.4 percent to 17.8 exajoules (EJ) in 2019, excluding traditional uses of biomass.12 Traditional uses of biomass in 2019 remained roughly stable globally, accounting for over 13 percent (23.5 EJ) of global heat consumption. Overall, as global heat demand continued to increase (rising 0.3 percent year-on-year), the share of modern renewables in global heat consumption reached just 10.1 percent, an improvement of less than 2 percentage points in 10 years.

As in 2018, renewable energy used in transport grew, rising 7 percent to 4.4 EJ in 2019, the largest increase in absolute terms since 2012. The increase brought the total share of renewable energy to 3.6 percent, up from 3.4 percent in 2018. Biofuels, primarily crop-based ethanol and biodiesel, supplied 91 percent of the renewable energy used in transport. The expansion of renewable electricity and sales of electric vehicles are pushing up the use of renewable electricity in transport, which grew to 0.03 EJ in 2019, the second-largest increase in a single year after 2018.

Significant regional disparities lie behind these global improvements (figure ES.6). Sub-Saharan Africa has the largest share of renewable sources in its energy supply, though traditional uses of biomass represent more than 85 percent of the renewable total. Excluding traditional uses of biomass, Latin America and the Caribbean is the region with the largest share of modern renewables in TFEC, thanks to significant hydropower generation, the consumption of bioenergy in industrial processes, and the use biofuels for transport. In 2019, 44 percent of the global year-on-year increase in modern renewable energy consumption took place in Eastern Asia —essentially in China—where hydropower, solar PV, and wind dominated growth. [1]

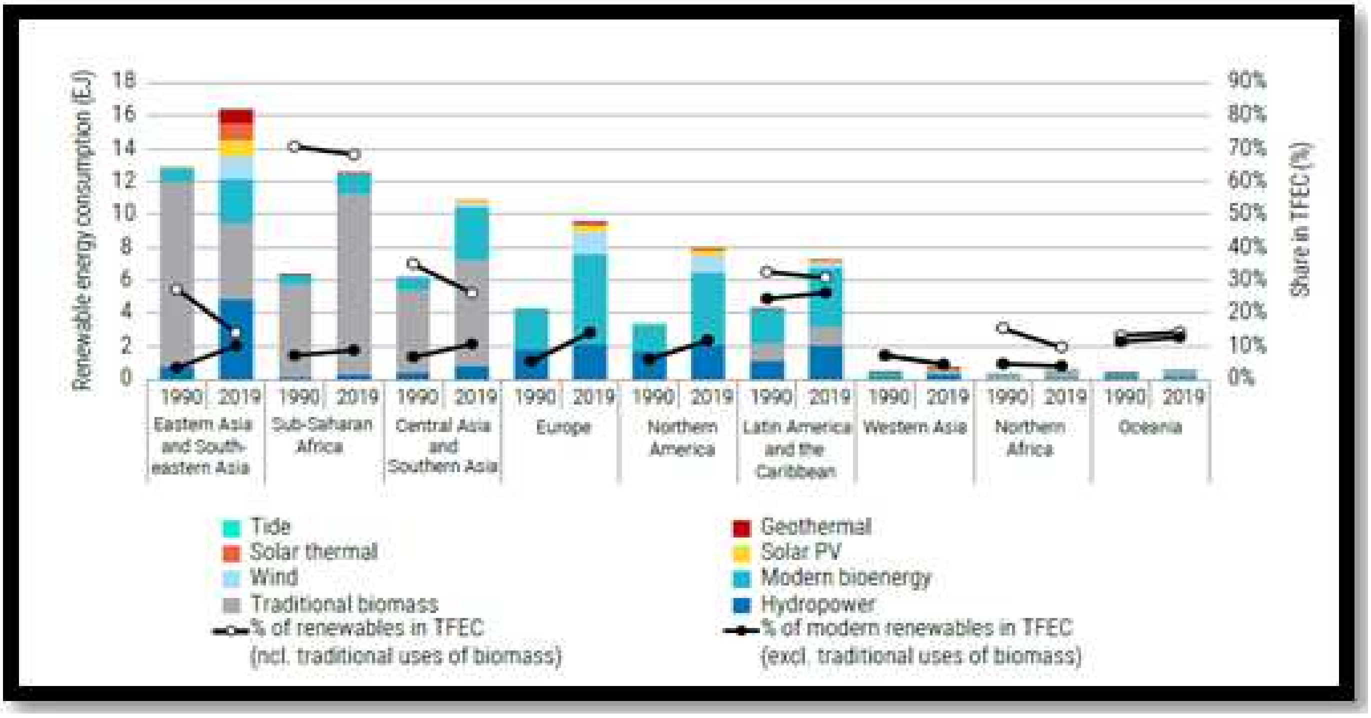

Figure 1 Renewable Energy consumption and share in total energy consumption by region from 1990 and 2019

Although the private sector finances most renewable energy investments, the public sector remains a critical source of finance, particularly for many developing countries. International public financial flows to developing countries in support of clean energy decreased in 2019 for the second year in a row, falling to USD#10.9 billion. This level of support was 23 percent less than the USD#14.2 billion provided in 2018, 25 percent less than the 2010–19 average, and less than half of the peak of USD#24.7 billion in 2017. Except for large fluctuations in 2016 for solar energy and 2017 for hydropower, the flows remain within the range of USD#10–16 billion per year since 2010 (figure 2).

India is a developing country and construction takes place in a very rapid rate. Electricity consumption should be in a limited range in every sector that may be industrial, agricultural and commercial as well as residential buildings.

So Government has taken so much initiatives in this field like amendments in the National building code and launches new building codes to reduce the energy consumption in building sector.

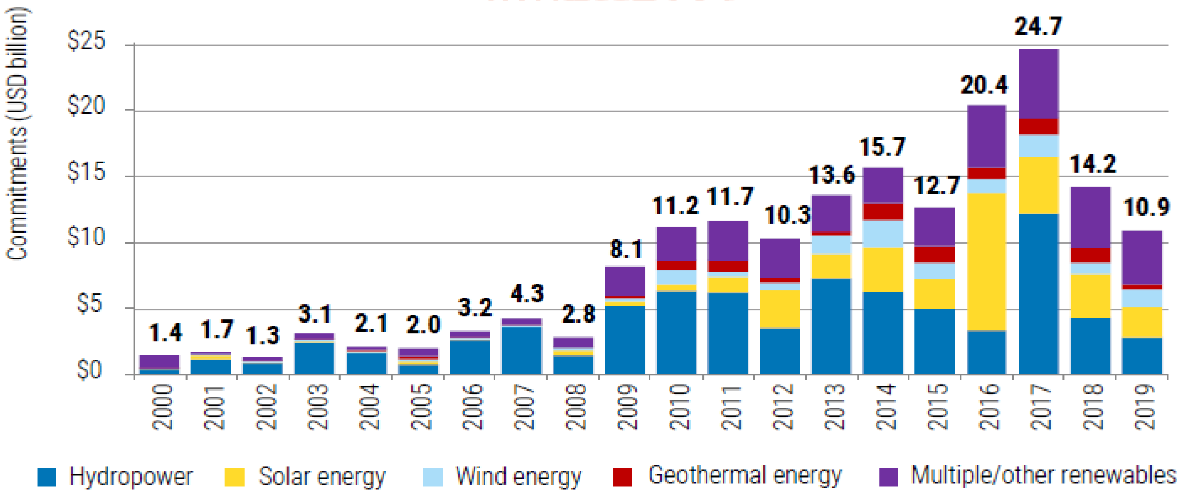

Figure 2 Increase in Renewable Energy Production

MODELLING OF PV ARRAY

Electrical Model of photovoltaic cell

Implements a PV array built of strings of PV modules connected in parallel. Each strings consists of strings connected in series. Parallel strings 40 and series connected modules per strings 10. With open circuit voltage 37.14V and short circuit current 8A.

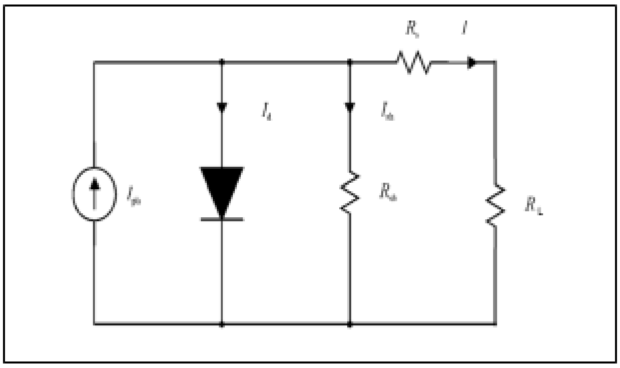

Figure 3 P-V cell Model

$I = I_D - I_{RP} - I_{ph}$ .... (1)

$I = I_{ph} - I_0 - \left[exp\left(\frac{V+IRs}{V_T}\right) - 1\right] - \left[\left(\frac{V+IRs}{R_p}\right)\right]$......... (2)

$I = n_p I_{ph} - n_p I_{rs} - \left[exp\left(\frac{q}{KTA} * \frac{V}{n_s}\right) - 1\right]$.......... (3)

$I_{rs} = I_{rr}\left[\frac{T}{T_R}\right]^3 exp\left(\frac{qE_G}{KA}\left[\frac{1}{T_r} - \frac{1}{T}\right]\right)$................. (4)

$E_G = E_G(0)\frac{\alpha T^2}{T+\beta}$...................................... (5)

$I_{ph} = [I_{scr} + K_i(T - T_r)]\frac{s}{1000}$........................ (6)

Iph is the Insolation current, I is the Cell current, I0 is the Reverse saturation current, V is the Cell voltage, Rs is the Series resistance, Rp is the Parallel resistance, VT is the Thermal voltage (KT/q), K is the Boltzmann constant, T is the Temperature in Kelvin, q is the Charge of an electron.

A system used to transform solar radiation directly into electricity. At the heart of a solar power system, also known as a photovoltaic (PV) system or solar electric system. The solar cell produces only a small amount of current and voltage. So, in order to meet a large load demand, the solar cell array has to be connected into modules and the modules

BOOST CONVERTER

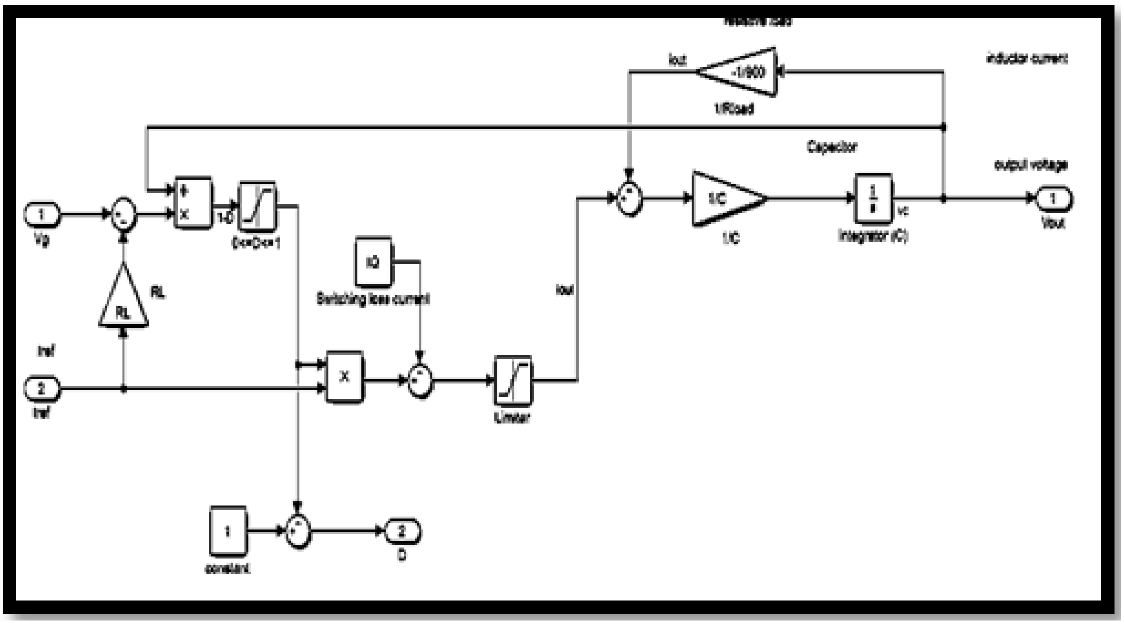

Figure 4 Subsystem Of boost converter

The PV system generates DC voltage in all the variable conditions of solar radiations. The generated voltage is low and variable and it must be somewhat high and constant at the input of inverter. So we need a boost converter device to boost the voltage as well it try to maintain constant boosted voltage.

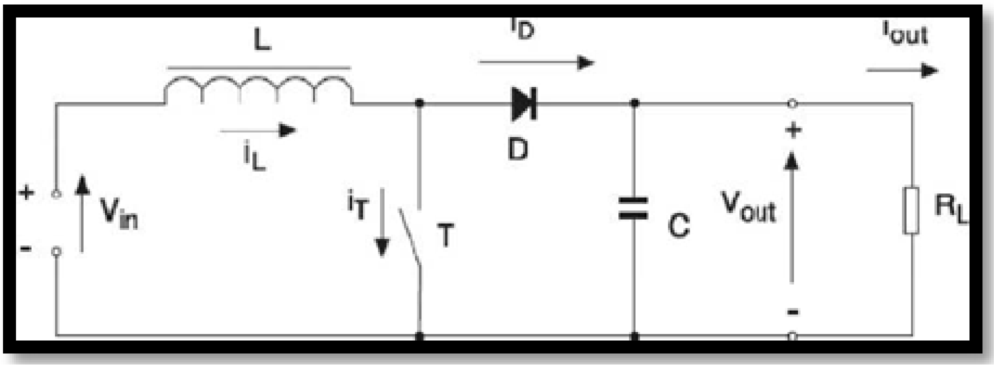

Figure 5 Circuit diagram of boost converter

The Fig. 5 shows a step up or PWM boost converter. This consists of a dc input voltage source VIN; boost inductor L controlled switch T, diode D, filter capacitor C and load resistance RL. When the switch S is in on state, the current in the boost inductor increases linearly and the diode D is off at that time, when the switch s is turned off, the energy stored in the inductor is released through the diode to the output RC circuit. The transfer function for the boost converter is [4]

MAXIMUM POWER POINT TRACKING The MPPT control is a fundamental in order to obtain a good performance on the overall system. The MPPT techniques can be categorised as direct and indirect methods. The direct method includes perturbation and observation method, fuzzy logic method, neural network method and incremental conductance method. In this work we review two different fuzzy logic control methods and trying to achieve optimum output by comparison in the overall installed system of such rating.

FUZZY CONTROL SYSTEM Fuzzy logic is a powerful tool since it allows the control of the system whose parameters are unknown or incomplete and as a result difficult to model mathematically. Fuzzy logic control consist of three main stages: input, processing and output. At the input stage membership functions are used to fuzzify the input values. The now fuzzified input is fed into the processing stage where an inference mechanism applied the appropriate rule from the knowledge base to come up with a set of fuzzy outputs. This output is then defuzzified using an appropriate technique. [14]

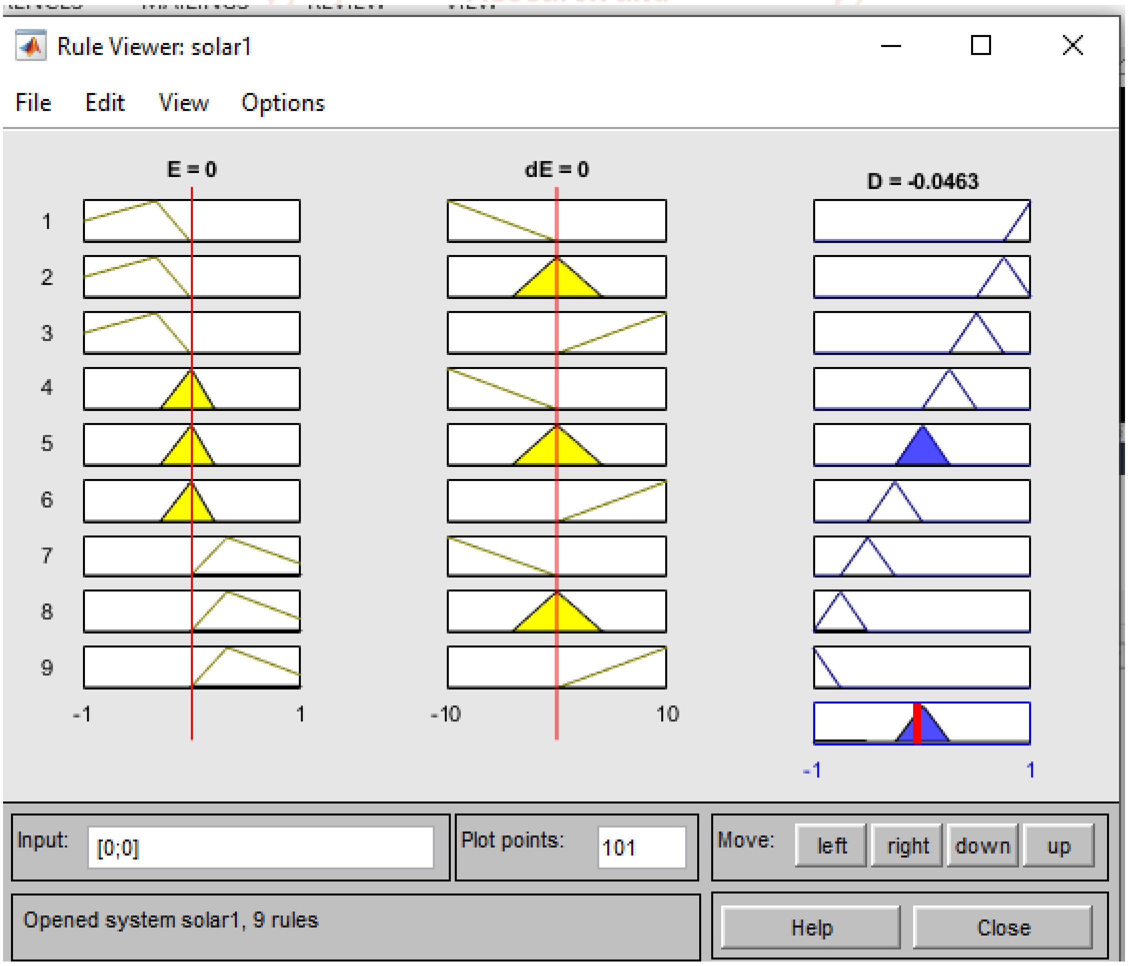

Figure 6 Rule View of initial control system

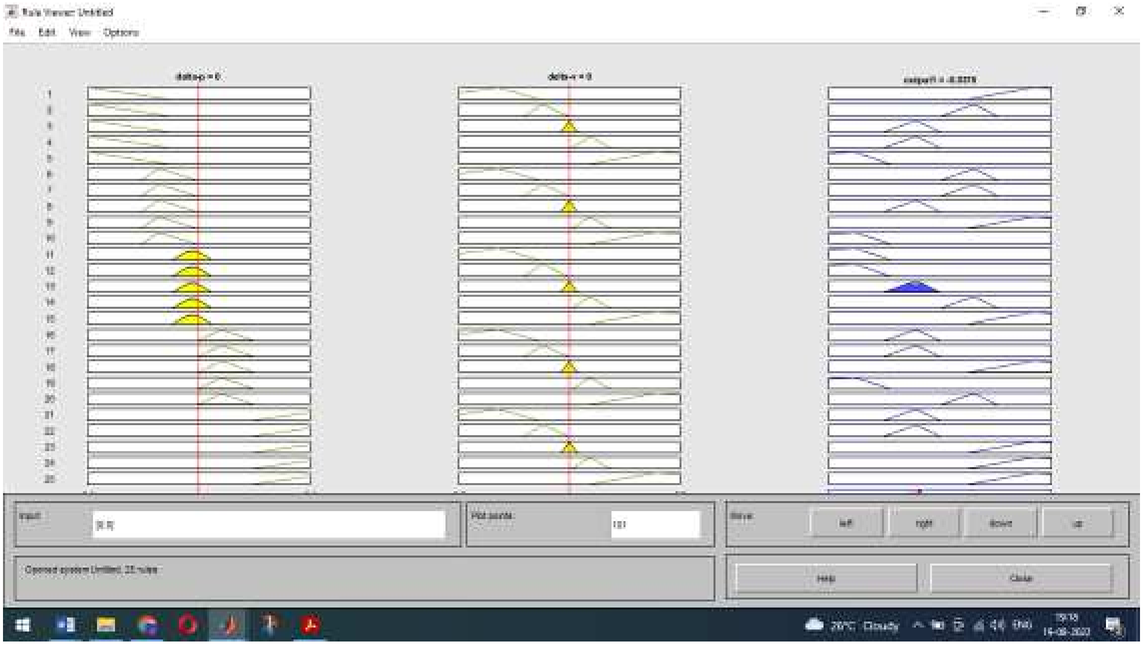

Figure 7 Rule View of final control system

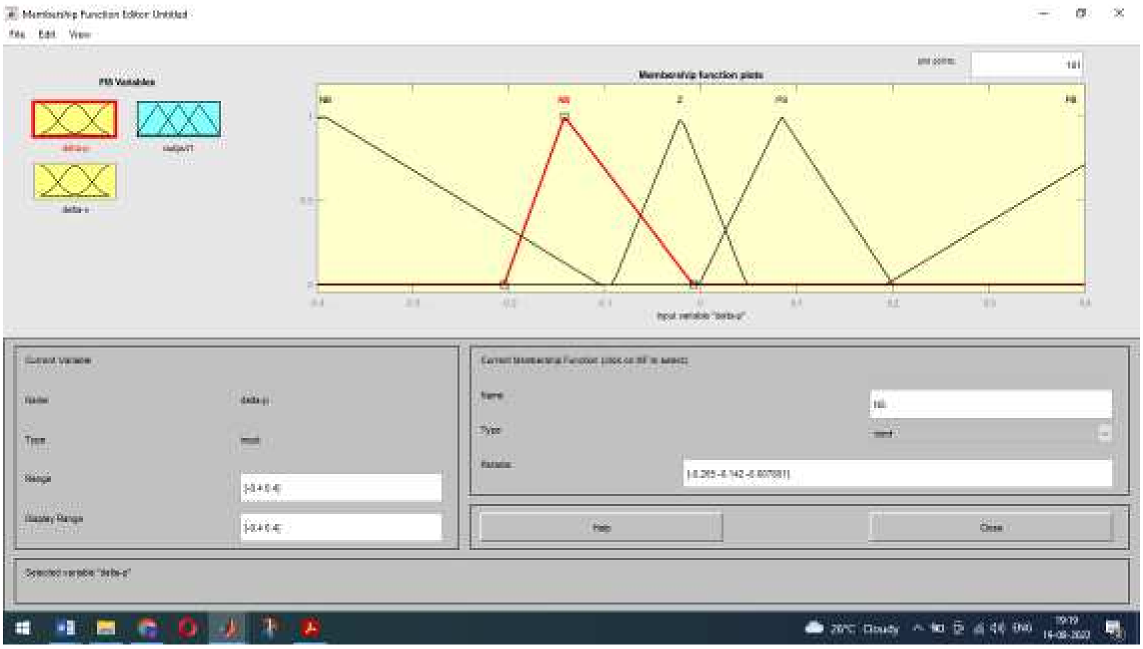

Figure 8 Input membership function 1

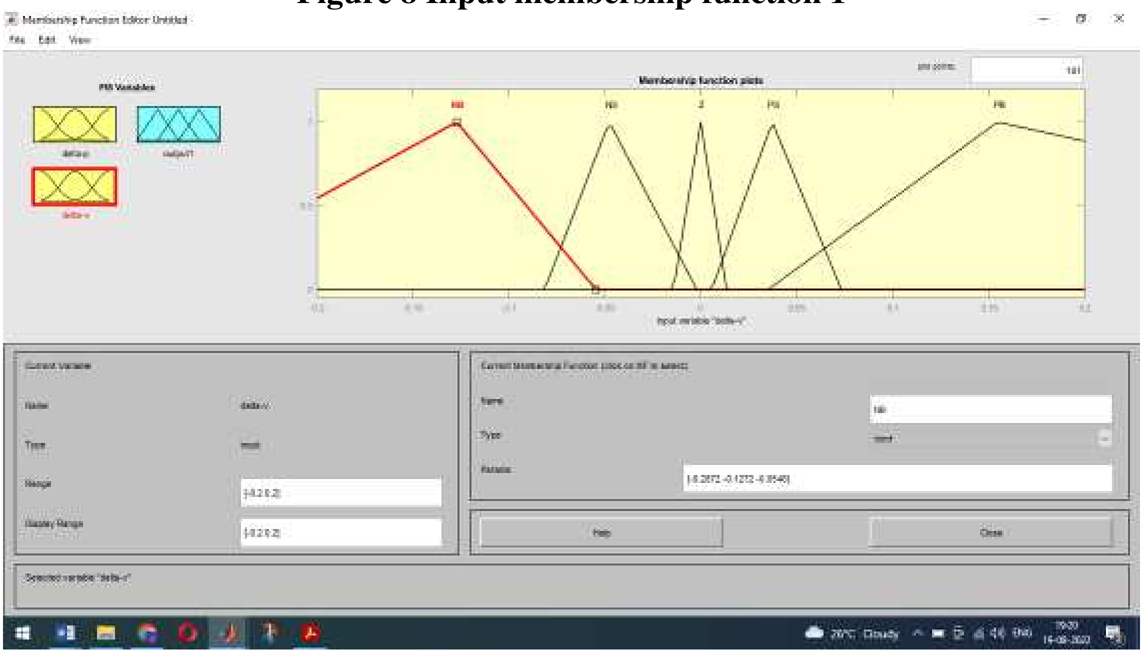

Figure 9 Input membership function 2

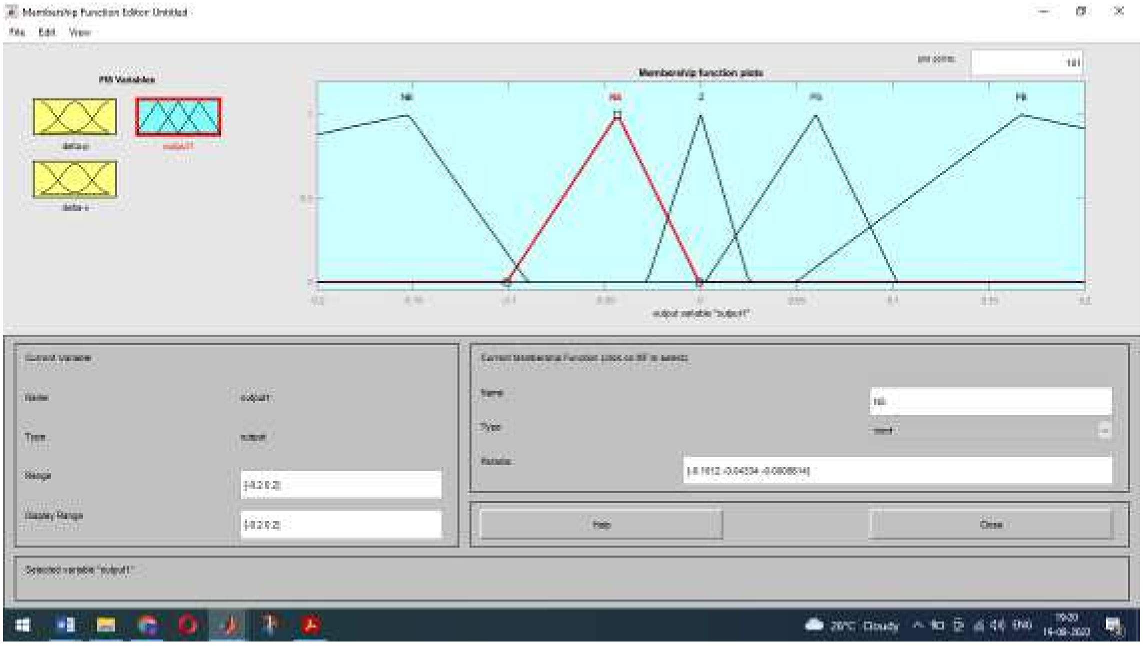

Figure 10 Output membership function Theta

In this model this fuzzy logic controller is initially connected to the MPPT controller. This fuzzy controller stores the MPPT file which contains the membership functions as input and rules to obtain the maximum output voltage from the solar PV module. The output of the fuzzy logic controller is given to the gate drive of the buck boost converter. The output of the fuzzy logic controller depends upon the membership function and rules designed.

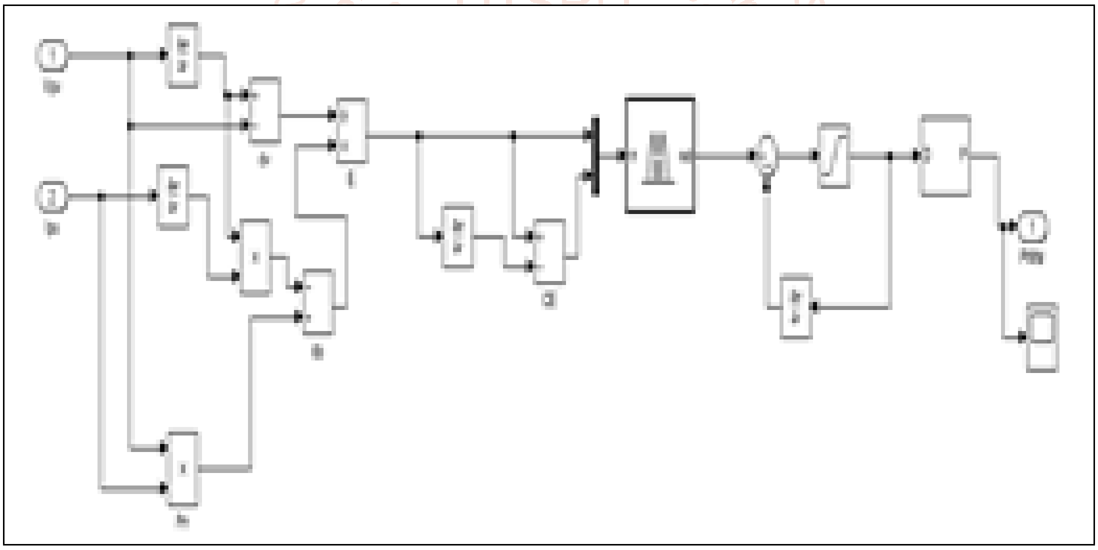

Figure 11 MPPT based on fuzzy logic system

Compares the unit reference sinusoidal signal with the triangular wave, which then generates the firing pulses as using PWM Modulation technique.The Vt and Vt ref likewise Vdc and Vdc ref passes through controller. The output of this controller then passes through the PWM generator. This PWM generator compares the sinusoidal signal with the triangular wave and then generates the firing pulses by PWM modulation technique.[5]

RESULTS

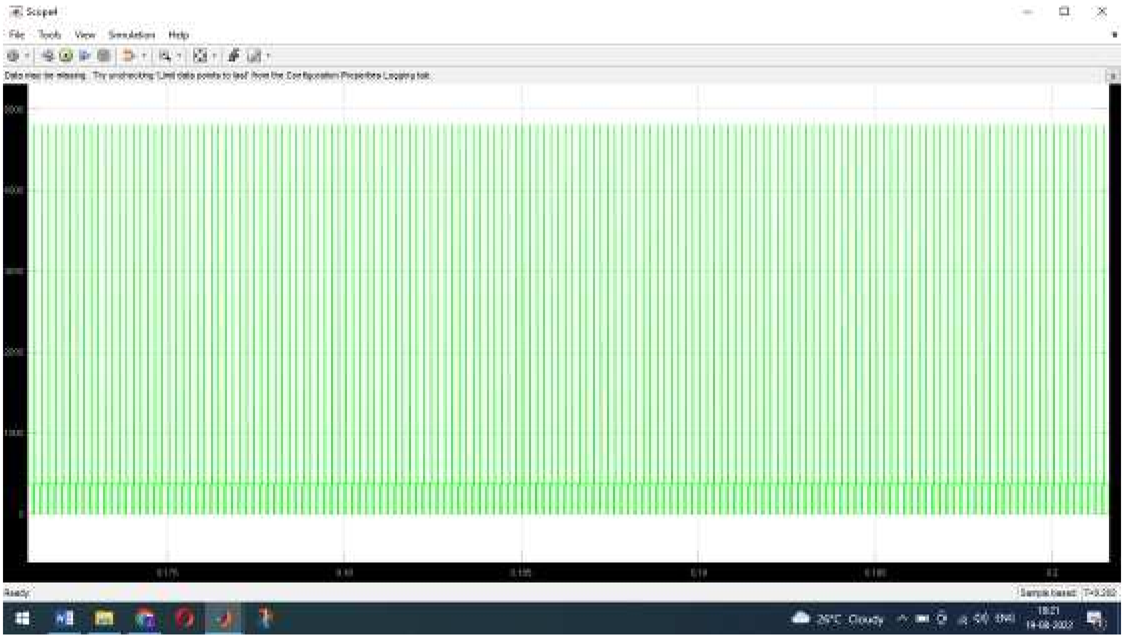

Figure 12 Initial Output Voltage

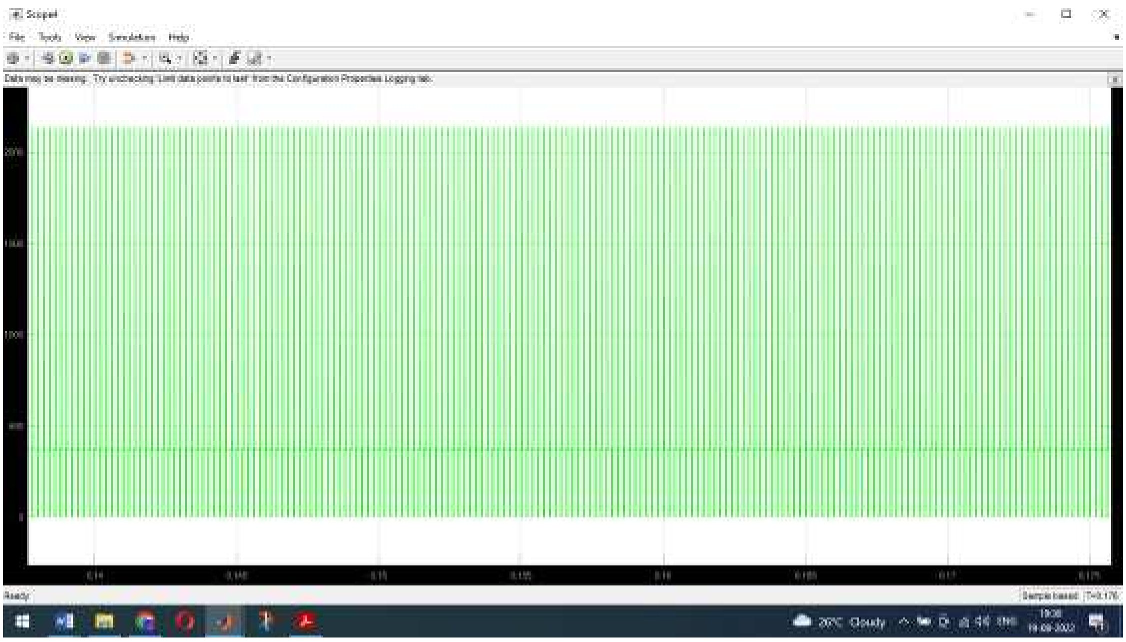

Figure 13 Output Voltage

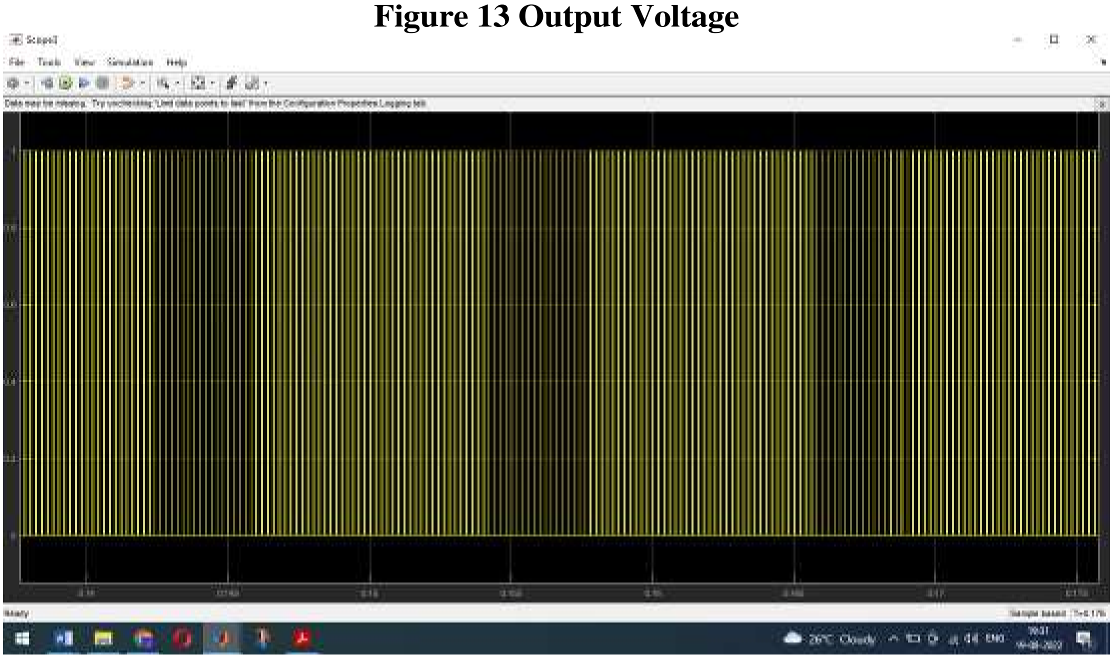

Figure 14 PWM Pulses

Figure 15 Initial Power from PV

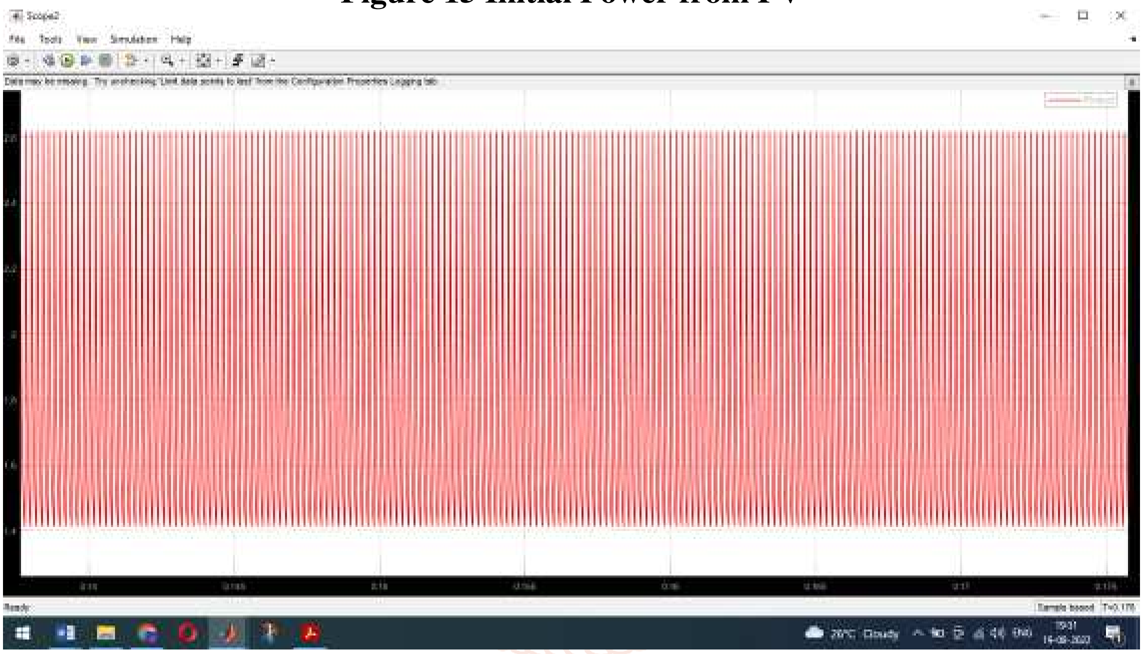

Figure 16 Power from PV

CONCLUSIONS

A solar PV has been designed with MPPT technique using two fuzzy control system from the reference papers for the control strategy. This simulation is done on Matlab Simulink software. Sice the research in the past has done many assumptions by using perturbation and observation, in this work we use fuzzy control system after analysis of the climatic condition of a particular location and its radiation intensity and sunny days a fuzzy control can be design accordingly and correlate it with the climatic condition to extract maximum power from the solar radiation.

A fuzzy control system is designed initially with rules and membership functions and the voltage came across nearby 4200 V but later on the control system with another rules and membership function in Mamdani type fuzzy control strategy has been designed and applied over the model and the result shows that Voltage output is lesser as compared to initial one nearby 2300 V. Different models with different rule sets behave accordingly so it is necessary to apply the research process to know the better control system with desired output. In the next level research will be done by converting this DC voltage into AC with the help of inverter configuration and connect this to the load or grid.

FUTURE APPLICATIONS

Let us consider a practical project in which the enhancement is possible. According to government the buildings designed in the future should comply all the codes with respect to energy conservation like green building codes or energy conservation building codes. In many states and union territories of India this code is notified and the

codes to be comply in the buildings are mandatory. In respect to this code if any building is constructed the solar panel should be installed as per the roof area or according to the total expected energy consumption of a year.

For example if the roof area is 100 square meters then the 25% of the roof area should be covered with the solar panel or if the total energy consumption of a year is near about 10,000 Kwh per year than 1% of connected load like 100 Kw capacity of solar Panel should be connected to meet the auxiliary demand.

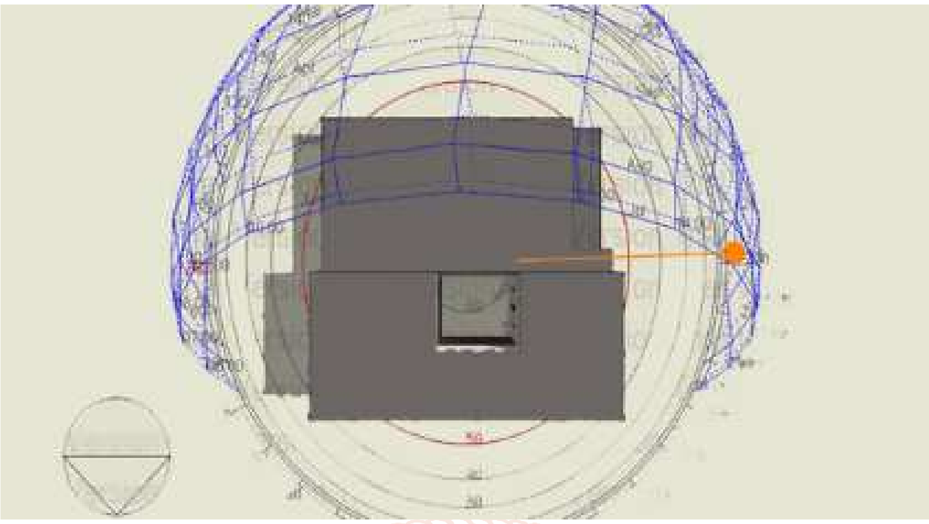

Figure 17 Sun path of a building

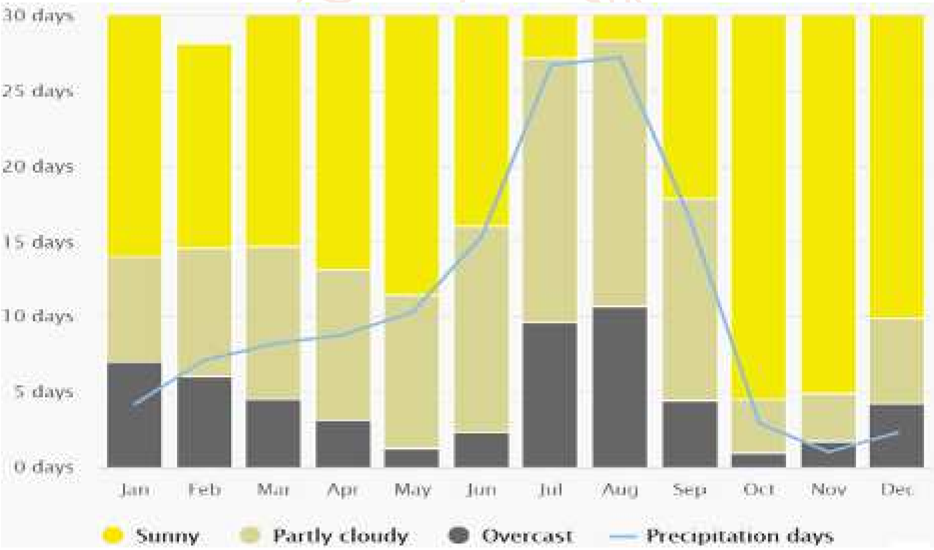

Figure 18 Climatic condition over a year

The methodology used in this paper basically depends upon the predetermined values of inputs and outputs. If the Solar Panels to be installed anywhere in the world the weather files are available in the government websites and the detailed analysis of the weather is also available. According to these analysis we can design the membership functions, rules and outputs. So in the form of PVB (positive very big), NB (Negative big), NS (Negative small) like this. So we can design an intelligent maximum power point tracking system by using fuzzy logic system with the predetermined set of rules and outputs. Now a days the efficiency of solar PV array are near about 15 to 20 %. We can increase this efficiency by using this maximum power point tracking system. We have taken an example from a site from the north India. We can do this analysis anywhere in the world and enhance the outputs.

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